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(11) **EP 1 589 120 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 158(3) EPC

(43) Date of publication:
26.10.2005 Bulletin 2005/43

(51) Int Cl.7: **C21D 1/00**

(21) Application number: **03812311.3**

(86) International application number:
PCT/JP2003/015120

(22) Date of filing: **27.11.2003**

(87) International publication number:
WO 2004/050922 (17.06.2004 Gazette 2004/25)

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HU IE IT LI LU MC NL PT RO SE SI SK TR**

(30) Priority: **29.11.2002 JP 2002348639**

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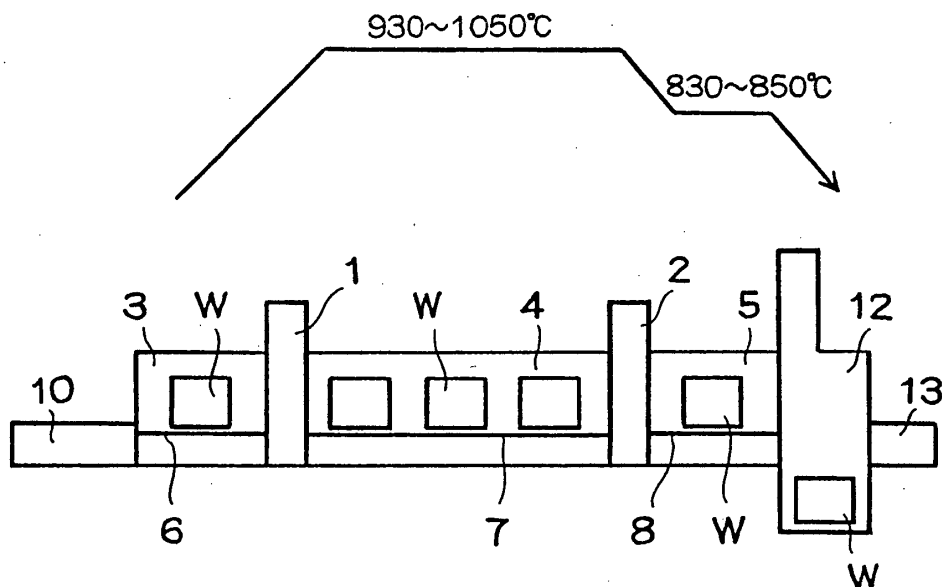
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(54) **METHOD AND FURNACE FOR HEAT TREATMENT**

(57) A linear furnace body of a heat treating furnace (1) houses in its inside a preheating chamber (3), a heat treating chamber (4) and a soaking chamber (5) with partitioning doors (1 and 2) arranged between them, respectively. Series of independently-driven hearth rollers (6, 7 and 8) are arranged in the chambers, respectively.

Upon preheating and soaking of a work W, the series of hearth rollers (6 and 8) in the preheating chamber (3) and the soaking chamber (5) are rotated forward and backward to vibrate the work W. Upon heating of the work W, the series of hearth rollers (7) in the heat treating chamber (4) is stopped.

Fig. 1



Description

Technical Field

[0001] The present invention relates to a method and furnace for heat treatment of a metal. More specifically, it relates to a method and a furnace for heat treatment using hearth rollers.

Background Art

[0002] Conventional heat treating furnaces using an in-furnace rail have a configuration shown in Fig. 5. Fig. 5 illustrates a charging platform 10, a heat treating chamber 11, an oil tank 12, an exit conveyer 13, and a work W (e.g., Japanese Patent No. 3103905).

[0003] Batch furnaces using the in-furnace rail when used in, for example, carburization require a much time for temperature rise, temperature fall and soaking and have insufficient production efficiency and thermal efficiency, since carburization (at 930°C to 1050°C) and temperature-fall-soaking (at 830°C to 850°C) are repeated in the same chamber. In addition, crossties of the in-furnace rail are bricks which are brittle and accumulate a large quantity of heat, and thereby the furnaces require a long seasoning time.

[0004] Certain batch furnaces using hearth rollers have, for example, the configuration shown in Fig. 6, in which the same components as in Fig. 5 have the same reference numerals. Fig. 6 illustrates a series of hearth rollers 14 (e.g., Japanese Unexamined Patent Application Publication No. 63-33552).

[0005] The batch furnaces using hearth rollers require a much time for temperature rise, temperature fall and soaking and have insufficient production efficiency and thermal efficiency, since carburization (at 930°C to 1050°C) and temperature-fall-soaking (at 830°C to 850°C) are repeated in the same chamber, as in the batch furnaces using the in-furnace rail. In addition, the furnaces of this type require a space for always rotating the series of hearth rollers 14 forward and backward when the work W resides therein, so as to prevent the series of hearth rollers 14 from deformation due to elevated temperatures in the heat treating chamber. Furthermore, they show large thermal radiation, since the both ends of the series of hearth rollers 14 penetrate the furnace wall.

[0006] Accordingly, an object of the present invention is to solve the conventional problems in the batch furnaces using the in-furnace rail or the hearth rollers having the configurations and to provide a method for heat treatment which has enhanced production efficiency and thermal efficiency and high cost effectiveness.

[0007] Another object of the present invention is to provide a heat treating furnace which is compact in size, is economical and is suitable for the method for heat treatment.

Disclosure of Invention

[0008] The present invention provides a method for heat treatment of a work in a heat treating furnace, the heat treating furnace containing a linear furnace body including, in its inside, a preheating chamber, a heat treating chamber and a soaking chamber, the chambers being partitioned by partitioning doors and having series of independently-driven hearth rollers, respectively, the method including the step of stopping the series of hearth rollers in the heat treating chamber during heat treatment of the work.

[0009] The method for heat treatment enables accurate control of the atmosphere and temperature in various heat treatments, since the inside of the furnace body is partitioned into the preheating chamber, the heat treating chamber and the soaking chamber by the partitioning doors.

[0010] In the conventional furnaces using hearth rollers, the series of hearth rollers is rotated forward and backward in the heat treating chamber, so as to prevent the series of hearth rollers from deformation caused by heating at high temperatures. In contrast, according to the present invention, the series of hearth rollers is not rotated backward, namely, is only rotated forward or inched in the heat treating chamber.

[0011] This saves a space for the reciprocating motion of the work, reduces the sizes of the heat treating chamber and the entire furnace body and increases agitation effectiveness of an atmosphere gas by an agitating fan. More specifically, it has been confirmed that the atmosphere gas has a more uniform distribution in its flow rate, and that the soaking in the heat treating chamber becomes increased. The heat variation in the conventional furnaces where the series of hearth rollers is rotated forward and backward is $\pm 7.5^{\circ}\text{C}$, but that in the down-sized furnace according to the present invention is within $\pm 6.0^{\circ}\text{C}$, indicating that the furnace according to the present invention enables improvements in quality of the resulting work as compared with the conventional furnaces.

[0012] The down-sizing of the heat treating chamber yields significant advantages, since the heat treating chamber stands at elevated temperatures during operation. Specifically, the down-sizing saves heaters and burners for heating, reduces their energy consumption and cost typically in electric power or gas and significantly reduces cost of, for example, heat insulating materials.

[0013] The present invention further provides, in another aspect, a method for heat treatment of a work in a heat treating furnace, the heat treating furnace containing a linear furnace body including, in its inside, a preheating chamber, a heat treating chamber and a soaking chamber, the chambers being partitioned by partitioning doors and having series of independently-driven hearth rollers, respectively, the method including the steps of rotating the series of hearth rollers in the

preheating chamber and the soaking chamber forward and backward to thereby vibrate the work during preheating and soaking of the work; and stopping the series of hearth rollers in the heat treating chamber during heat treatment of the work.

[0014] The heat treating method just mentioned above enables supply of a uniformly preheated work to the heat treating chamber and enables accurate soaking of the work after heat treatment in a heat treating method in which the series of hearth rollers in the heat treating chamber is stopped during heat treatment of the work.

[0015] In yet another aspect, the present invention provides a heat treating furnace, a linear furnace body of which includes, in its inside, a preheating chamber, a heat treating chamber and a soaking chamber, the chambers being partitioned by partitioning doors and having series of independently-driven hearth rollers, respectively. In the furnace, the series of hearth rollers in the preheating chamber and the soaking chamber are so configured as to be rotated forward and backward, and the series of hearth rollers in the heat treating chamber is so configured as to be rotated forward alone. Accordingly, only forward rotation or inching of the series of hearth rollers is carried out in the heat treating chamber.

[0016] The heat treating method according to the present invention can easily carry out heat treatment by using the heat treating furnace. In addition, the heat treating furnace can reduce the sizes of the heat treating chamber and the entire furnace body, since there is no need of a space for reciprocating motion of the work in the heat treating chamber. The down-sizing of the heat treating chamber can significantly reduce cost.

[0017] In the heat treating furnace according to another embodiment of the present invention, the series of hearth rollers in the heat treating chamber is made from a material containing a refractory steel, the refractory steel further containing trace amounts of tungsten, cobalt and titanium so as to have improved creep properties.

[0018] The heat treating furnace does not require, in contrast to conventional equivalents, the forward and backward rotation of the series of hearth rollers in the heat treating chamber to prevent deformation thereof and can carry out heat treatment of the work while stopping the hearth roller. The furnace therefore does not require a space for the reciprocating motion of the work and can have a reduced size. In addition, the furnace can reduce heat radiation from the both ends of the series of hearth rollers penetrating the furnace wall, since the series of hearth rollers can have a reduced diameter.

[0019] In yet another embodiment of the heat treating furnace of the present invention, the wall of the furnace body includes a brick layer, a silica layer and a layer compression-molded article derived from titanium oxide and an inorganic fiber. This heat treating furnace can have reduced thermal diffusion and increased insulation

effectiveness of the furnace wall and can yield economical advantages due to reduced heating energy. In addition, the furnace can have a reduced thickness in its wall and a reduced length of the series of hearth rollers so as to further effectively prevent the deformation of the hearth roller.

Brief Description of the Drawings

[0020]

Fig. 1 is a schematic side view of a heat treating furnace according to the present invention with an example of carburization process.

Fig. 2 is a schematic side view of the heat treating furnace according to the present invention with an example of soft nitriding process.

Fig. 3 is a schematic side view of the heat treating furnace according to the present invention with an example of thermal refining process.

Fig. 4 is a sectional view of furnace wall of the heat treating furnace according to the present invention with an adiabatic temperature curve.

Fig. 5 is a schematic side view of a conventional batch furnace using a rail.

Fig. 6 is a schematic side view of a conventional batch furnace using a hearth roller.

Best Mode for Carrying Out the Invention

[0021] A heat treating furnace 1 according to one of preferred embodiments of the present invention comprises a linear furnace body which includes, in its inside, a preheating chamber 3, a heat treating chamber 4 and a soaking chamber 5, which are partitioned by partitioning doors 1 and 2 as shown in Figs. 1 to 3. The figures also illustrate a charging platform 10, a heat treating chamber 11, an oil tank 12 and an exit conveyer 13. In the illustrated example, the ratio in size of the preheating chamber 3 to the heat treating chamber 4 and that of the soaking chamber 5 to the heat treating chamber 4 are preferably set at 1:3. This can yield a production about three times as much as that of conventional heat treating furnaces, although the total length of the furnace is set being substantially equal to that of the conventional equivalents.

[0022] The preheating chamber 3, the heat treating chamber 4 and the soaking chamber 5 have series of independently-driven hearth rollers 6, 7 and 8, respectively. In addition, the series of hearth rollers 6 and 8 in the preheating chamber 3 and the soaking chamber 5 are so configured as to be rotated forward and backward, and the series of hearth rollers 7 in the heat treating chamber 4 is so configured as only to be rotated forward and inched.

[0023] The series of hearth rollers 7 in the heat treating chamber 4 of the heat treating furnace 1 comprises a material containing a refractory steel. The refractory

steel further contains trace amounts of tungsten, cobalt and titanium and thereby has improved creep properties. This eliminates the necessity of repeating the forward and backward rotation of the series of hearth rollers 7 in the heat treating chamber 4 so as to prevent its deformation, in contrast to the conventional equivalents. The furnace therefore saves a space for the reciprocating motion of the work W in the heat treating chamber 4, and the heat treating chamber and the entire heat treating furnace can be down-sized. In addition, the furnace can reduce heat radiation from the both ends of the series of hearth rollers penetrating the furnace wall, since the series of hearth rollers can have a reduced diameter, such as 90 mm, as compared with a conventional one, such as 104 mm.

[0024] The series of hearth rollers 6 and 8 in the preheating chamber 3 and the soaking chamber 5 can comprise the same material as that of the series of hearth rollers 7 in the heat treating chamber 4.

[0025] The deformation, typically bent, of the series of hearth rollers is significantly affected by the strength of the hearth roller, as well as by the difference between the temperature of work W and the temperature inside the furnace (in-furnace temperature). The difference between the temperature of work W and the in-furnace temperature is large in the preheating chamber 3. Accordingly, the deformation of the series of hearth rollers 7 can be minimized by allowing the series of hearth rollers 6 in preheating chamber 3 to rotate forward and backward to thereby reduce the difference in temperature and then feeding the work W to the heat treating chamber 4.

[0026] The deformation of conventional hearth rollers and that of the series of hearth rollers according to this embodiment were compared in a heat treating chamber of a carburization furnace. As a result, the conventional hearth rollers had a bent of 2 mm or less at the time of setting but a bent of 5 mm or more after use for three months and must be replaced. In contrast, the hearth rollers according to this embodiment had a bent of 0.3 mm at the time of setting and a bent of 1 mm or less even after use for eight months, and there was no need of replacing.

[0027] The bents were each determined by measuring the distances between the center point and points 75 mm inside the flanges at the both ends of a sample hearth roller using a dial gauge. The bent of the conventional hearth roller was measured before and after repetitive forward and backward rotation, and that of the hearth roller according to this embodiment was measured before and after inching (stopping and forward rotation) alone.

[0028] Fig. 4 is a sectional view of furnace wall of the heat treating furnace according to the present invention with an adiabatic temperature curve. More specifically, the furnace wall comprises a brick layer 15 having a thickness of 115 mm, a silica layer 16 having a thickness of 85 mm, and a compressed molded article 17 of titania-

oxide and an inorganic fiber having a thickness of 50 mm, in this order from the inside of furnace. The adiabatic temperature curve shows that the surface temperature of furnace body is 50.2°C (atmospheric temperature: 20°C) while the in-furnace temperature is held to 950°C, indicating that the furnace can be significantly reduced in its wall thickness and can save energy.

[0029] The heat treating furnace 1 can be used in various heat treatments of metals. Fig. 1 shows an example of carburization. Specifically, a work W is fed onto the charging platform 10, fed to the preheating chamber 3 via a charging door (not shown), and the series of hearth rollers 6 in the preheating chamber 3 is rotated forward and backward to thereby preheat the work W uniformly.

[0030] The partitioning door 1 between the preheating chamber 3 and the heat treating chamber 4 is then opened, the series of hearth rollers 6 and 7 are operated, and the work W is conveyed to the heat treating chamber 4, followed by carburization at a set temperature of 940°C in a set atmosphere at a carbon potential of 1.0% for a set time of 540 minutes. The carburization in the heat treating chamber 4 of the heat treating furnace shown in Figs. 1 to 3 is carried out while the series of hearth rollers 7 is not rotated backward but is stopped. Specifically, the work W is subjected to carburization by rotating forward or inching the series of hearth rollers 7 in the heat treating chamber 4 to thereby sequentially move the work W to a set position in the heat treating chamber 4. In this procedure, the series of hearth rollers 7 is not rotated backward.

[0031] More specifically, the series of hearth rollers 7 in the heat treating chamber 4 is rotated forward or inched so as to allow three blocks of the work W to reside in the heat treating chamber 4 for 540 minutes for carburization, respectively. The three blocks of the work W are capable of conveying to and charging in the heat treating chamber 4. One block of the work W after the completion of carburization is conveyed to the soaking chamber 5, and another block of the work W before carburization is fed from the preheating chamber 3 to the heat treating chamber 4.

[0032] The partitioning door 2 between the heat treating chamber 4 and the soaking chamber 5 is opened, and the work W after the completion of carburization in the heat treating chamber 4 is conveyed to the soaking chamber 5 by the action of the series of hearth rollers 7 and 8. The work W undergoes temperature fall and soaking at a set soaking temperature, for example, 850°C, while rotating the series of hearth rollers 8 in the soaking chamber 5 forward and backward.

[0033] A door (not shown) between the soaking chamber 5 and the oil tank 12 is then opened, followed by quenching of the work W. At the time when the quenching is completed, an exit door (not shown) is opened and the work W is conveyed to the exit conveyor 13.

[0034] As is described above, charging into the preheating chamber 3, transfer from the preheating cham-

ber 3 to the heat treating chamber 4, transfer from the heat treating chamber 4 to the soaking chamber 5, transfer from the soaking chamber 5 to the oil tank 12, and export of the work W from the oil tank 12 to the exit conveyer 13 are continuously carried out efficiently, resulting in an increased production efficiency.

[0035] Fig. 2 shows an example of soft nitriding using the heat treating furnace 1. Specifically, a work W is fed onto the charging platform 10, fed to the preheating chamber 3 via a charging door (not shown), and the series of hearth rollers 6 in the preheating chamber 3 is rotated forward and backward to thereby preheat the work W uniformly. The partitioning door 1 between the preheating chamber 3 and the heat treating chamber 4 is then opened, the series of hearth rollers 6 and 7 are operated, and the work W is conveyed to the heat treating chamber 4, followed by soft nitriding, for example, at a set temperature of 550°C in a set atmosphere of RX gas and ammonia gas for a set time of 120 minutes.

[0036] After the completion of the soft nitriding for a set time in the heat treating chamber 4, the partitioning door 2 between the heat treating chamber 4 and the soaking chamber 5 is opened, and the work W is conveyed to the soaking chamber 5 by the action of the series of hearth rollers 7 and 8. Then, a door (not shown) between the soaking chamber 5 and the oil tank 12 is opened, and the work W without soaking is subjected to quenching. At the time when the quenching is completed, an exit door (not shown) is opened and the work W is conveyed to the exit conveyer 13.

[0037] Fig. 3 shows an example of thermal refining using the heat treating furnace 1. Specifically, a work W is fed onto the charging platform 10, fed to the preheating chamber 3 via a charging door (not shown), and the series of hearth rollers 6 in the preheating chamber 3 is rotated forward and backward to thereby preheat the work W uniformly. The partitioning door 1 between the preheating chamber 3 and the heat treating chamber 4 is then opened, the series of hearth rollers 6 and 7 are operated, and the work W is conveyed to the heat treating chamber 4, followed by thermal refining, for example, at a set temperature of 880°C in a set atmosphere at a carbon potential of 0.3% to 0.5% for a set time of 30 minutes.

[0038] The following processes are as in the soft nitriding, and the work W is subjected to quenching without soaking process.

[0039] The present invention can provide a method for heat treatment with increased production efficiency and thermal efficiency, and a heat treating furnace for carrying out the method having a reduced size and economical efficiency.

comprising a linear furnace body including, in its inside, a preheating chamber (3), a heat treating chamber (4) and a soaking chamber (5), the chambers (3, 4 and 5) being partitioned by partitioning doors (1 and 2) and having series of independently-driven hearth rollers (6, 7 and 8), respectively, the method comprising the step of stopping the series of hearth rollers (7) in the heat treating chamber (4) during heat treatment of the work (W).

2. A method for heat treatment of a work (W) in a heat treating furnace (1), the heat treating furnace (1) comprising a linear furnace body including, in its inside, a preheating chamber (3), a heat treating chamber (4) and a soaking chamber (5), the chambers (3, 4 and 5) being partitioned by partitioning doors (1 and 2) and having series of independently-driven hearth rollers (6, 7 and 8), respectively, the method comprising the steps of rotating the series of hearth rollers (6 and 8) in the preheating chamber (3) and the soaking chamber (5) forward and backward to thereby vibrate the work (W) during preheating and soaking of the work (W); and stopping the series of hearth rollers (7) in the heat treating chamber (4) during heat treatment of the work (W).
3. A heat treating furnace comprising a linear furnace body including, in its inside, a preheating chamber (3), a heat treating chamber (4) and a soaking chamber (5), the chambers (3, 4 and 5) being partitioned by partitioning doors (1 and 2) and having series of independently-driven hearth rollers (6, 7 and 8), respectively, wherein the series of hearth rollers (6 and 8) in the preheating chamber (3) and the soaking chamber (5) are so configured as to be rotated forward and backward, and wherein the series of hearth rollers (7) in the heat treating chamber (4) is so configured as to be rotated forward alone.
4. The heat treating furnace according to claim 3, wherein the series of hearth rollers (7) in the heat treating chamber (4) comprises a material containing a refractory steel, the refractory steel further containing trace amounts of tungsten, cobalt and titanium so as to have improved creep properties.
5. The heat treating furnace according to claim 3 or 4, wherein the wall of the furnace body comprises a brick layer (15), a silica layer (16), and a layer (17) comprising a compression molded article derived from titanium oxide and an inorganic fiber.

Claims

1. A method for heat treatment of a work (W) in a heat treating furnace (1), the heat treating furnace (1)

Fig. 1

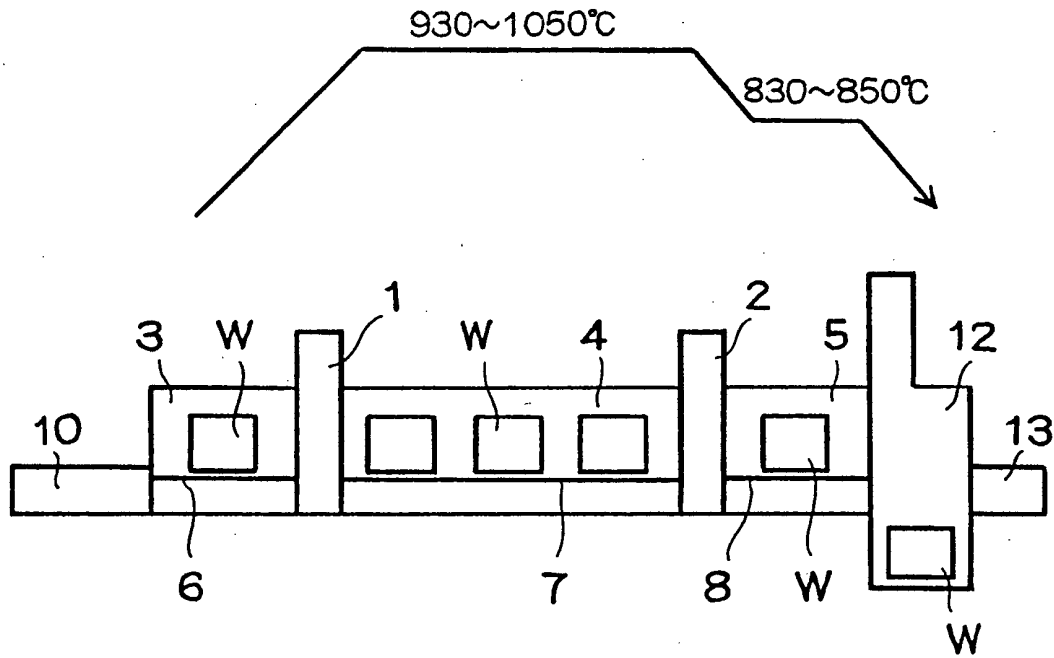


Fig. 2

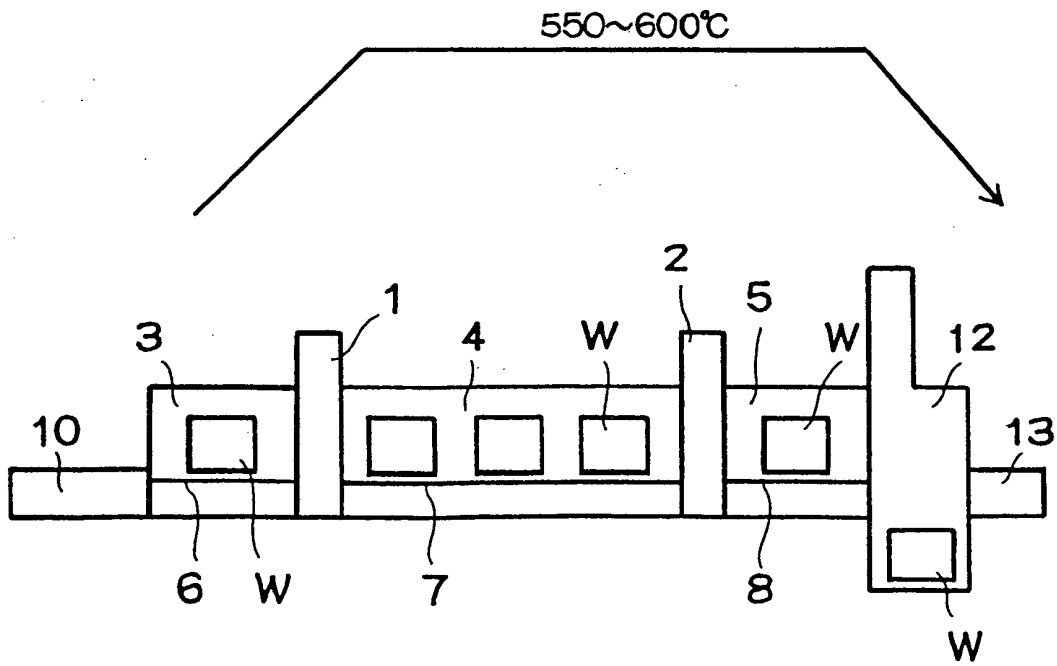


Fig. 3

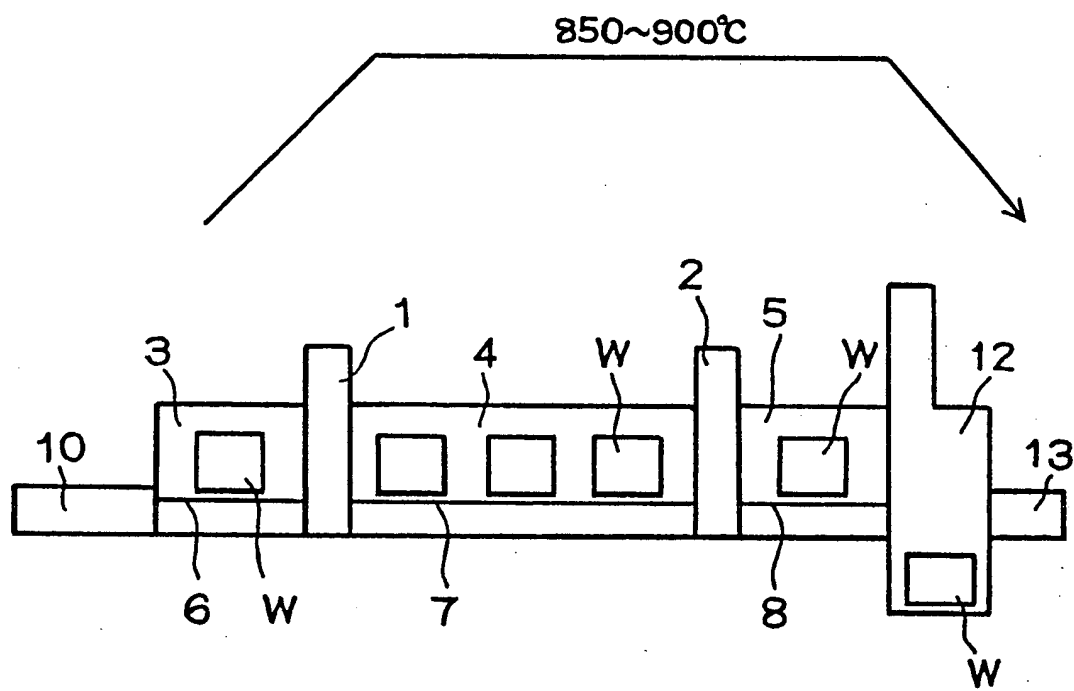


Fig. 4

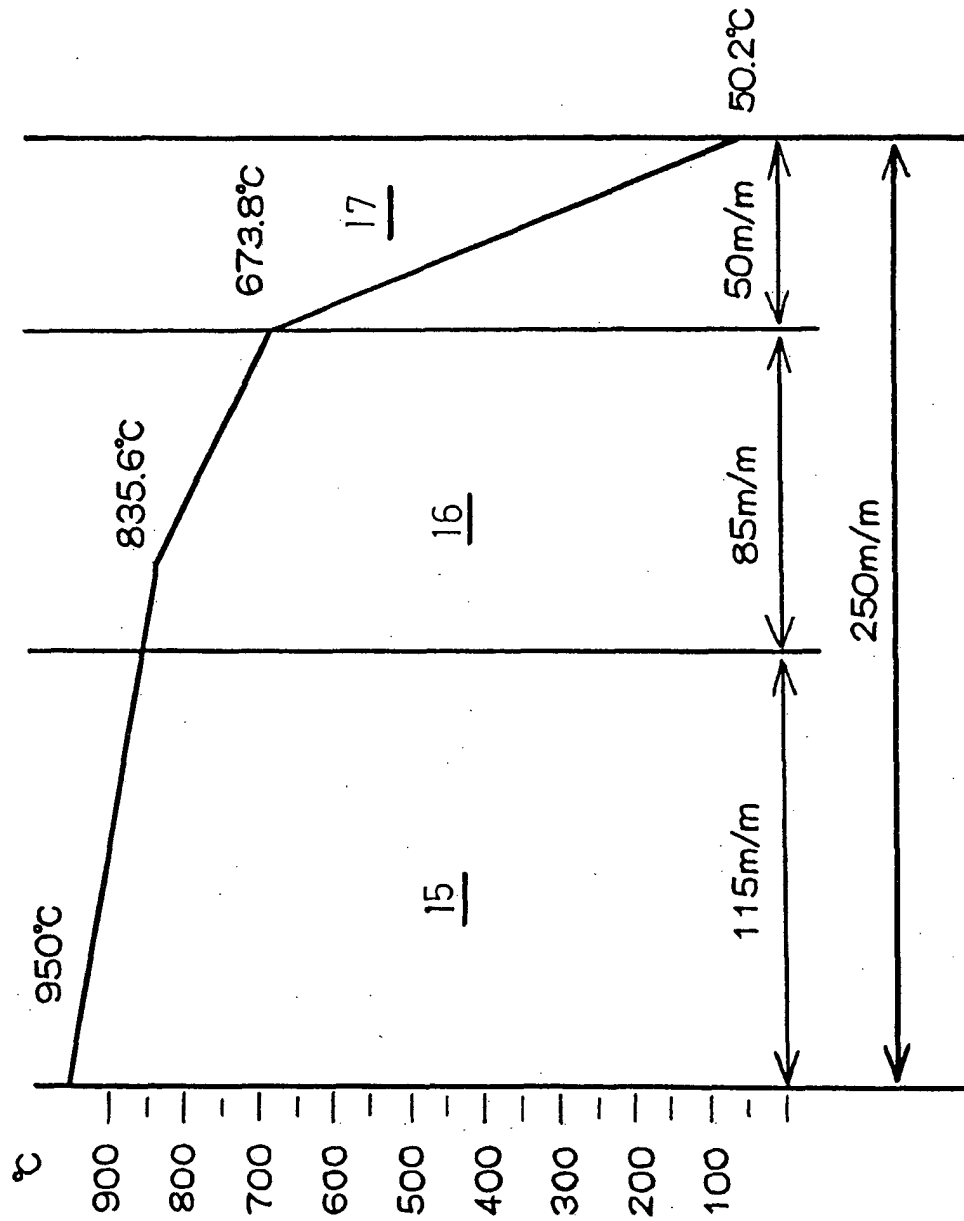


Fig. 5

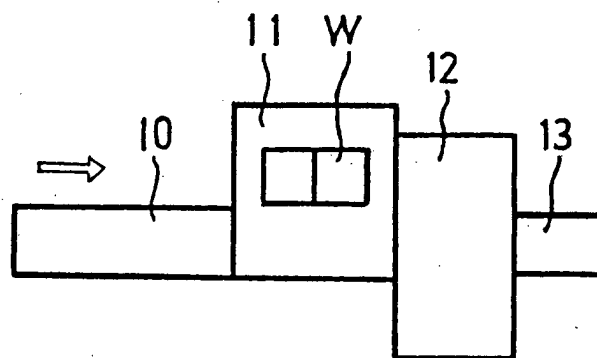
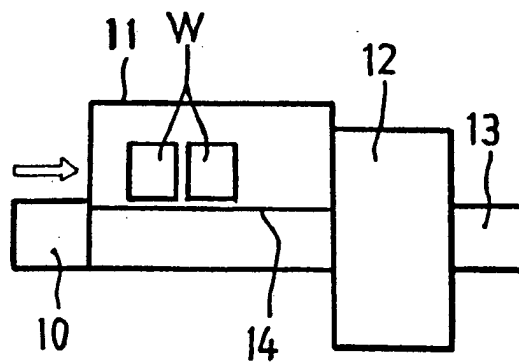


Fig. 6



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP03/15120

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl.⁷ C21D1/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl.⁷ C21D1/00, F27B9/00-9/40, F27D1/00-1/18Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Toroku Jitsuyo Shinan Koho 1994-2004
Kokai Jitsuyo Shinan Koho 1971-2004 Jitsuyo Shinan Toroku Koho 1996-2004

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 168788 B1 (Chugai Ro Co., Ltd.), 27 June, 1990 (27.06.90), Full text & US 4627814 A & JP 61-16910 B2	1-5
Y	JP 6-22358 U (Ishikawajima-Harima Heavy Industries Co., Ltd.), 22 March, 1994 (22.03.94), Par. No. [0013] (Family: none)	1-5
A	JP 2001-200311 A (Nippon Steel Corp.), 24 July, 2001 (24.07.01), Full text (Family: none)	1-5

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search
18 February, 2004 (18.02.04)Date of mailing of the international search report
09 March, 2004 (09.03.04)Name and mailing address of the ISA/
Japanese Patent Office

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP03/15120

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 55-6686 B2 (Daido Steel Co., Ltd.), 19 February, 1980 (19.02.80), Full text (Family: none)	1-5

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